Bayou Bonfouca Marsh Creation Project
PO-104

95% Design Report

October, 2012

Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA)

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1.0 INTRODUCTION

The Bayou Bonfouca Marsh Creation Project (PO-104) is located in the Lake Pontchartrain Basin along the northeastern shoreline of Lake Pontchartrain as shown in Figure 1. The Louisiana Coastal Wetlands Planning, Protection and Restoration Task Force designated PO-104 as part of the 20th Priority Project List. The United States Fish and Wildlife Service (USFWS) was designated as the lead federal sponsor with funding approved through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) of 1990 by the United States Congress and the Wetlands Conservation Trust Fund by the State of Louisiana. The Louisiana Coastal Protection and Restoration Authority (CPRA) will serve as the local sponsor and perform engineering and design.

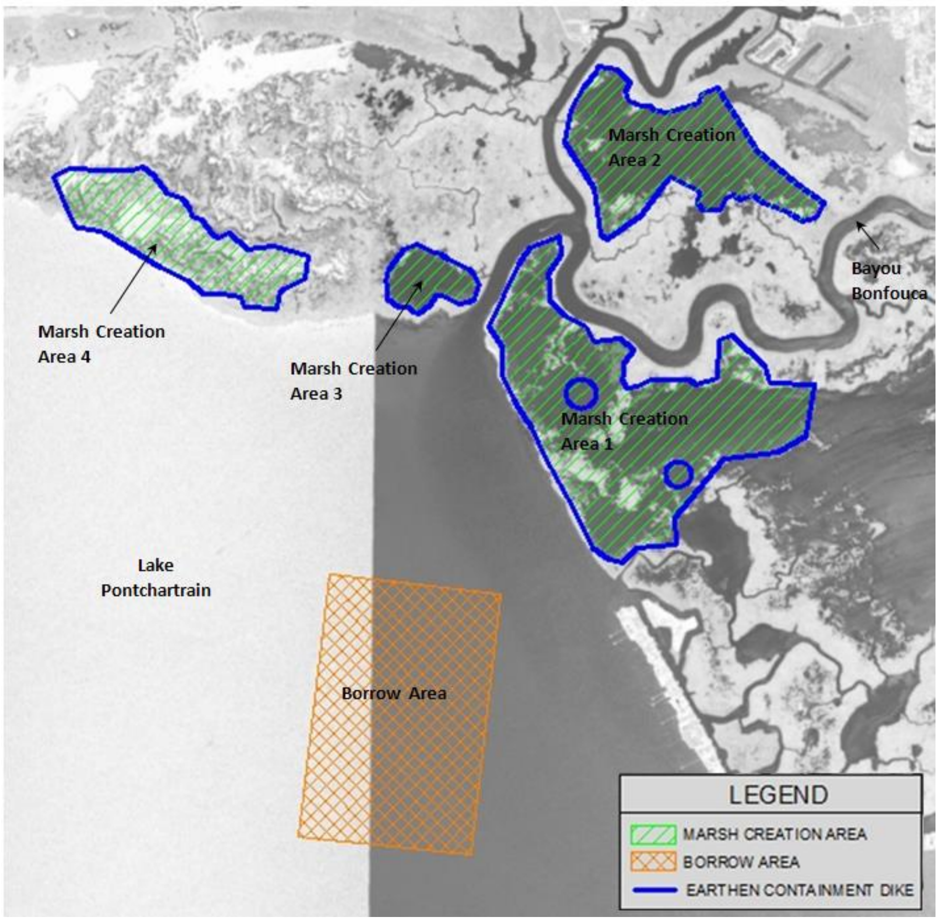


Figure 1 – Project Layout

The primary goal of PO-104 is to re-create and nourish approximately 639 acres of low salinity brackish marsh in open waters adjacent to Bayou Bonfouca with sediment dredged from Lake Pontchartrain.

The poor condition of this marsh is due to a combination of subsidence, hurricane induced ponding, and shoreline erosion. Although the shoreline erosion rates are relatively low, only a narrow strip of shoreline currently exists between Lake

Pontchartrain and the interior ponds. Several breaches are known to exist along the shoreline. Should shoreline breaching and enlargement of tidal channels allow high tidal energy to intrude into the interior ponds of the project area, the interior marshes will experience an accelerated loss rate. Restoration of the marsh adjacent to Lake Pontchartrain would provide vital protection to the interior marsh to the north.

The project team, consisting of members of USFWS, CPRA, St. Tammany Parish Government, and Big Branch Marsh National Wildlife Refuge, performed an on-site kick-off meeting on April 21, 2011. Based on that meeting, a plan was developed to identify and address all of the project requirements. The engineering and design, environmental compliance, real estate negotiations, operation/maintenance planning, and cultural resources investigation have been completed to the 95% design level as required by the CWPPRA Standard Operating Procedures.

2.0 SURVEYS

2.1 Horizontal and Vertical Control

The secondary monument 876 1534 B TIDAL provides survey control for the project. The monument is located to the southeast of the project site (See Figure 2) with coordinates 30°13'44.3989 N, 89°51'05.24823 W. A static GPS session was performed at the monument during each day of surveying. The information was then downloaded into the NOAA Online Positioning User Service (OPUS) to confirm the elevation of the monument. The data sheet for the monument is provided in Appendix A.

2.2 Marsh Creation Area and Borrow Area Surveys

C & C Technologies, Inc. performed the surveys of the borrow area, marsh creation areas and pipeline corridor from August 11, 2011 through October 11, 2011. Survey transects were taken in open water, across marsh areas and extended 100 feet past existing marsh along the perimeter of the marsh creation areas. Elevations were obtained at twenty five foot (25') intervals (approx.) along the prescribed transects as shown in Figure 2.

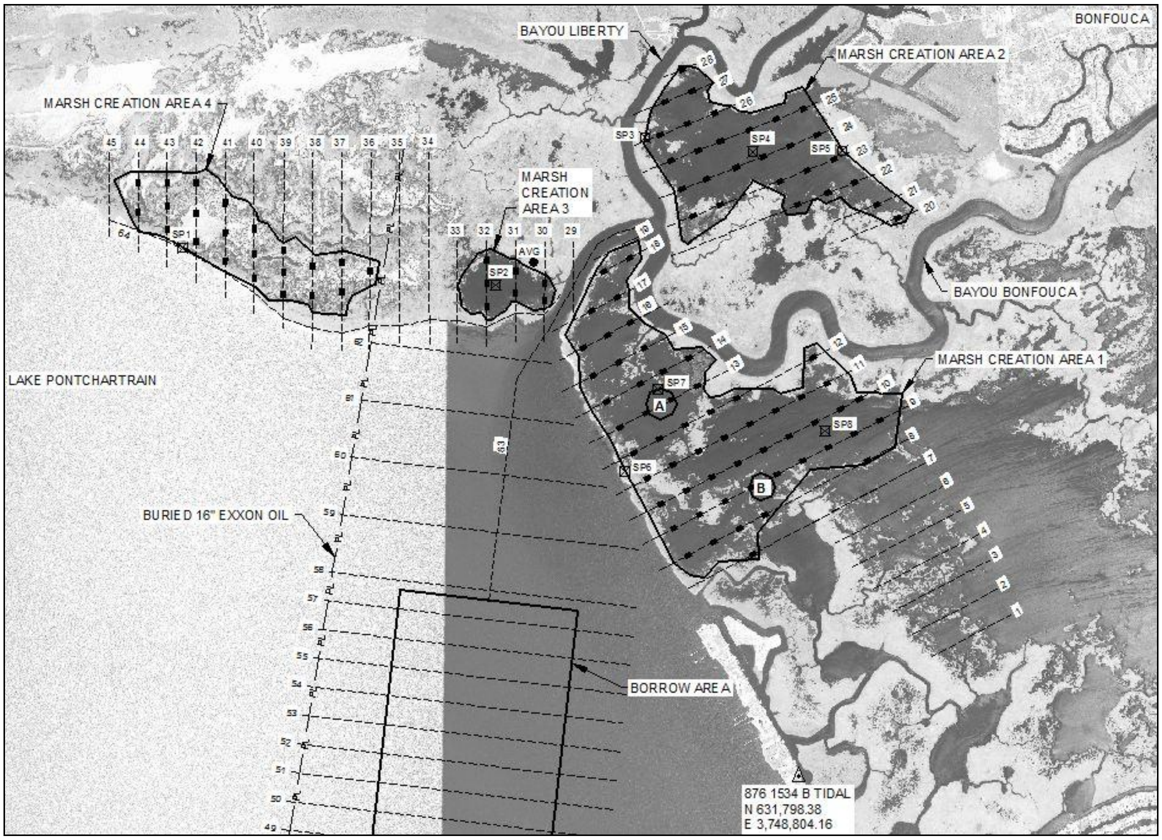


Figure 2: Survey Transect Locations

2.3 Marsh Elevation Survey

In order to determine the average healthy marsh elevation for the project, transects were surveyed in areas that appeared to contain healthy marsh. Additionally, spot elevations were also collected from other areas that appear to contain healthy marsh. All of this data was used to calculate an average healthy marsh elevation equal to 0.94 ft as shown in Table 1. This average healthy marsh elevation is consistent with the Goose Point Project (PO-33) located immediately west of this project.

Table 1: Healthy Marsh Elevations

Location	Average Healthy Marsh Elevation (ft NAVD 88)
Transect 17	1.14
Transect 16	0.90
Transect 24	0.91
General Marsh Survey	0.80
Average	**0.94**

2.4 Magnetometer Survey

The magnetometer survey was conducted utilizing a cesium magnetometer to collect data along 500 foot transects. The magnetometer dataset was collected at a sampling rate of 10 Hz and a very high sensitivity of less than 0.1 gammas. The amplitude and duration of a magnetic anomaly is dependent on several factors such as the ferromagnetic content of the object, its shape, size, and distance from the sensor.

The magnetometer survey identified one buried 16-inch Exxon pipeline near the project area as shown in the Plans. The magnetometer also identified 218 magnetic anomalies within the borrow area that did not correlate to any known infrastructure. Some of the magnetic anomalies are relatively small (less than 10 gammas) and are likely geologic in origin. These magnetic anomalies exhibit amplitudes between 5 and 1,806 gammas and durations between 11 and 93 feet. The locations of all magnetic anomalies should be taken into consideration by the Contractor when dredging the lake borrow area.

2.5 Geophysical Survey

Geophysical operations were conducted by utilizing the M/V *C-Star* on August 11 and 12, 2011. Geophysical instruments utilized for the shallow hazards survey included an Edgetech SB-424 Chirp Seismic Profiler (4 to 24 kHz), an Odom Hydrotrac Fathometer, and a Geometrics 882 Cesium Magnetometer. Survey vessel positioning was accomplished using Leica Geosystems' SmartNet real-time kinematic (RTK) GPS and provided RTK positions in real time with centimeter accuracy. In addition, C & C Technologies' C-NAV® L-Band globally corrected differential GPS (DGPS) was employed as a secondary positioning system and provided DGPS positions in real time with sub-meter accuracy and provided vessel positions if RTK signal was lost.

The uppermost lake floor sediments were recorded by a subbottom profiler as one seismic stratigraphic unit which is continuous throughout the study area. The subbottom profiler records show an area exhibiting chaotic bedding reflections. The acoustically chaotic bedded sediment area is interpreted to consist of reworked coarse-grained sediment (e.g., sandy-silty muds). This area had limited penetration which is potentially due to the chaotic sediments. In addition, the subbottom profiler data was also attenuated by the presence of biogenic gas. Biogenic gas occurs in marsh environments and results from the decay of organic matter. The gas consists of low concentrations of carbon dioxide. The low pressure gas attenuates seismic signals and may reduce the shear strength of the soils where present.

Numerous relic submarine channels were identified throughout the project area. The subbottom profiler records show the relic submarine channels as dipping reflectors with an infill of high amplitude reflections. These high amplitude reflections suggest the channel fill is coarser sediment than the surrounding sediment and underlying channel. The relic submarine channels occur just below the mud line with associated thalwegs depths ranging from 1 to 4 feet below the lake bottom.

3.0 GEOTECHNICAL ANALYSIS

A geotechnical investigation and analysis was conducted by GeoEngineers Inc. in order to determine the suitability and physical characteristics of the soils in the project area. Soil borings were collected within the marsh creation areas and lake borrow area as shown in Figure 4. Laboratory tests and analyses were performed in order to determine the characteristics of the soils, slope stability of the earthen containment dikes and containment dike borrow areas, settlement of the earthen containment dikes and marsh creation areas, and the cut-to-fill ratio for the dredge slurry.

3.1 Soils Investigation

In an effort to minimize redundant geotechnical work and cost, a preliminary qualitative sediment review of the borrow area was performed by the CPRA. In the preliminary sediment survey, sediment samples were collected and classified in several locations where the lake bottom was near the -10 foot contour. The samples were collected using a PVC coring device designed and constructed to sample the top 5 to 10 cm of the lake bottom. The locations of the samples are shown in Figure 3.

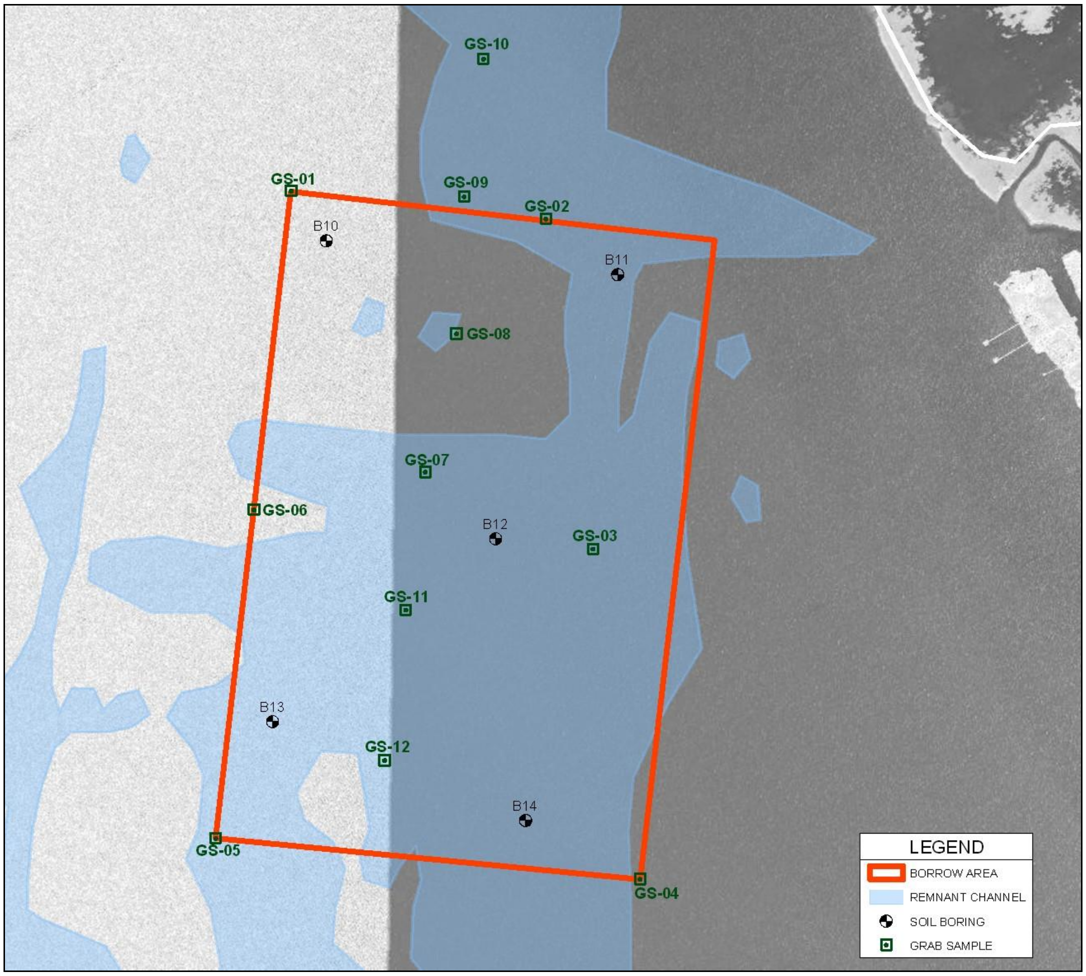


Figure 3: Locations of Boring and Lake Bottom Grab Samples

All of the samples were characterized as primarily “mud” consisting of clay, silts and organic matter. Some sand was present but no attempt was made to determine the ratio of mud to sand in the samples. The sand size component of the samples was evaluated using U.S. Standard Sieve Series #50 and #200. The #50 sieve will not allow particles larger than 0.297 mm to pass through the sieve and the #200 will not allow particles larger than 0.074 mm to pass the sieve. These two particle size limits correspond in size terms, using the Wentworth grain size classification nomenclature, to “very fine sand” at between 0.0625 mm - 0.125 mm for the #200 sieve and “medium sand” at between 0.25 mm - 0.5 mm for the #50 sieve. If both sieves captured sand then the sample would be termed a “very fine to medium sandy mud”. If no sand was recovered in the #50 sieve but was recovered in the #200 sieve, then the sample would be termed a “very fine to fine sandy mud”. The determination of color can be subjective (color charts were not used) but is a basic part of any lithological classification. Samples that smelled of hydrogen sulfide or contained what appeared to be, fine organic material or both, were termed “organic” mud. The term “slightly” implies the component is a small part of the sample. Bivalve shells, Rangia, and small shell fragments were a relatively common but small component of the samples. A description of each grab sample is shown below in Table 2.

Sample #	Description
#01	grey, slightly shelly, very fine sandy mud
#02	grey, very fine to medium sandy mud
#03	dark grey, slightly very fine sandy, organic mud
#04	grey, very fine to medium sandy mud (w/ bivalves)
#05	dark grey and brown, very fine to fine sandy organic mud
#06	dark grey, very fine to medium sandy, organic mud
#07	dark grey and brown, very fine to medium sandy, organic mud (w/ included bivalves)
#08	grey, very fine to medium mud (w/ bivalves)
#09	grey, very fine to medium sandy mud
#10	dark grey to black, slightly very fine sandy, organic mud
#11	dark grey and brown, very fine to medium sandy, organic mud
#12	grey, very fine to medium sandy, organic mud

Table 2 Lake Pontchartrain Sediment Samples

The results of the qualitative analysis show that the lake bottom in the borrow area is relatively free of sand. A more detailed and quantitative evaluation of the soil conditions was performed. Five (5) soil borings were advanced to an approximate depth of 20 feet below mud line within the confines of the proposed borrow area. The approximate soil boring locations are shown in Figure 4. Also, nine (9) soil borings with depths ranging from approximately 40 to 60 feet below existing mud line were advanced within the proposed marsh creation areas.

The soil borings were performed in 0.5 to 11.5 feet of water. Samples were collected continuously in the upper 20-feet of the soil and on 5-foot centers thereafter to boring completion depths. The borings were completed between August 30 and September 13, 2011 using pontoon and marsh buggy-mounted drill rigs. A geologist from GeoEngineers managed the drilling on a full time basis, examined and classified the soils encountered, obtained representative samples, and prepared a log of each borehole.

Figure 4 – Soil Borings Locations

After transport to GeoEngineers' soil mechanics laboratory, Shelby tube samples were tested for miniature vane shear strength and removed from their tubes. Laboratory tests included soil compressive strength, moisture content, organic content, grain size analysis, specific gravity, consolidation with rebound, and Atterberg limits. Soil characteristics observed during drilling and laboratory test results are located on the soil boring logs in Appendix D.

3.2 General Geologic Evaluation

Subsurface conditions vary widely across the project area. Generally there is very soft organic clay and peat followed by inorganic clay, silt, or sand. Interface depths vary significantly from boring to boring. In all but two of the borings, medium to stiff clays were encountered within the top 20 feet of the soil profile and continued through the completion depth of the boring, except where interrupted by sand and silt layers. This is consistent with geological maps of the area which place the surface of Pleistocene deposits within 20 feet of the ground surface. Clay samples from soil borings B-2 and B-3 remained very soft through the completion depth of the borings. This may indicate the presence of an ancient channel through the Pleistocene materials which subsequently filled with softer Holocene material.

3.3 Slope Stability Analysis

Slope stability analyses were performed on proposed earthen containment dikes. The slope stability of any embankment or dike has two types of driving forces: (1) the forces induced by the soil weight, and (2) any seepage forces which tend to cause the soil to slide. In response to these driving forces, the subsurface soils have a resistant force in the form of shear strength, which attempts to keep the slope from sliding. Both the driving forces and the resisting forces are dependent on the geometry of the situation: the “Failure Surface.” GeoEngineers, Inc. performed stability analyses that compute factors of safety against potential failure based on the limit equilibrium theory.

As evidenced by the soil properties in the boring logs, the Bayou Bonfouca Marsh Creation Project rests over relatively shallow Pleistocene deposits. This underlying soil layer has a low-moisture content, low organic content, and is over consolidated. These factors translate to improved slope stability and low consolidation settlement. The soil characteristics of borings B2 and B3 appear to be exceptions. Soil borings B2 and B3 exhibit weaker soil strength which also correlates to higher settlement rate. This may be attributed to their close proximity to a relic channel.

Table 3 shows the results of slope stability calculations based on the proposed construction marsh fill elevations. No geo-textile reinforcement was required to attain the factors of safety shown.

Soil Boring identification	Proposed Construction Marsh Fill Elevations (ft, NAVD 88)	Design Crown Elevation (ft, NAVD 88)	Assumed Foundation Elevation (ft, NAVD 88)	Acceptable Crown Width (ft, NAVD 88)	Acceptable Side Slopes	Slope Stability Factor of Safety
B-1	2.5	4.0	0	5	3H:1V	1.84
B-2	3.0	4.0	0	5	3H:1V	1.22
B-3	2.5	5.0	0	5	3H:1V	1.47
B-4	2.5	5.0	-1.5	5	3H:1V	1.13
B-5	2.5	4.0	0	5	3H:1V	2.45
B-6	2.7	4.0	0	5	3H:1V	1.77
B-8	2.7	4.0	-1	1	7H:1V	1.14
B-9	2.7	4.0	-1	5	5H:1V	1.46

Table 3: Earthen Containment Dike Slope Stability

In order to minimize potential stability problems during construction of the earthen containment dikes, construction should be performed in two or more lifts to ensure gentle application of pressure on area soils. Stockpiling of fill material in one location to allow it to dewater will not be allowed, as a large pile of soil with steep slopes could result in bearing failure of the foundation soils.

Two ponds have been included for Marsh Creation Area 1. A fill differential of only 2 feet was used in calculating the stability of the earthen containment dike for these features. Refer to Section 7.3 for the construction process necessary to limit the fill differential.

3.4 Marsh Creation Area Settlement Analysis

A settlement analysis was performed to determine the marsh construction fill elevation and the total volume of material required to fill the four marsh creation areas. The final elevation of the marsh fill (at year twenty) is governed by two forms of settlement; (1) the settlement of the underlying soils in the marsh creation areas caused by the placement of the dredged material, and (2) the self-weight consolidation of the dredged material (See Figure 5). Data from low pressure consolidation tests were used to calculate the time-rate of settlement of the underlying soils of the marsh creation areas. Self-weight consolidation tests were performed on a composite sample from the borrow area material (borings B-10 through B-14) to determine the consolidation of the dredged material.

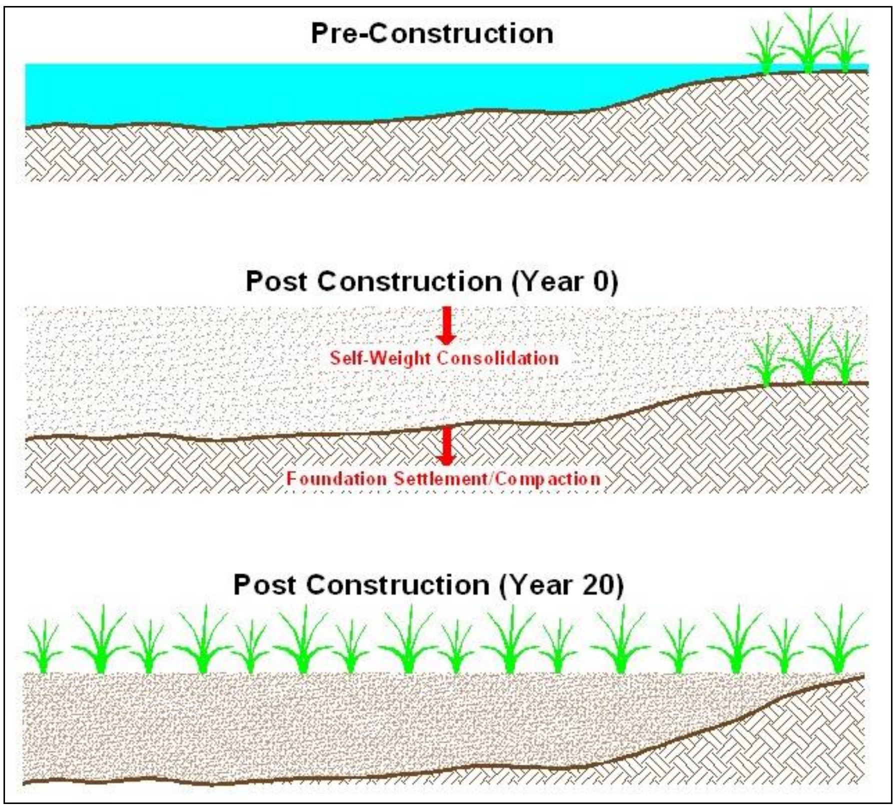


Figure 5: Marsh Fill Settlement

Settlement curves were developed in 0.5ft increments for proposed construction marsh fill elevations ranging from +2.0 feet to +4.5 feet NAVD 88. These settlement curves show the changes in elevation over the 20 year design life of the project and were used to compare the different construction marsh fill elevations.

The settlement for Boring B-7 which is located on the western portion of Marsh Creation Area 1 is shown in Figure 6. There is very little settlement expected after 6 months, which is favorable for the project over the 20 year project life. The construction fill elevation of each marsh creation area is adjusted to the settlement curves associated with that area.

For Marsh Creation Area 1 a construction marsh fill elevation of +2.7 feet NAVD 88 will be sufficient to reach the construction fill elevation.

After review of the geotechnical results in Marsh Creation Area 2, it was determined that additional work was required in Marsh Creation Area 2. This work was intended to locate a transitional point between the weaker soils noted near boring B-3 and the stronger soils found near boring B-4. A series of Cone Penetrometer Tests (CPT's) were performed between the two zones in an effort to determine the extents of the weaker soils. It was determined that a small area, approximately 17 acres, if filled to the upper end of the fill tolerance and will settle less than 0.3 feet below the remaining marsh

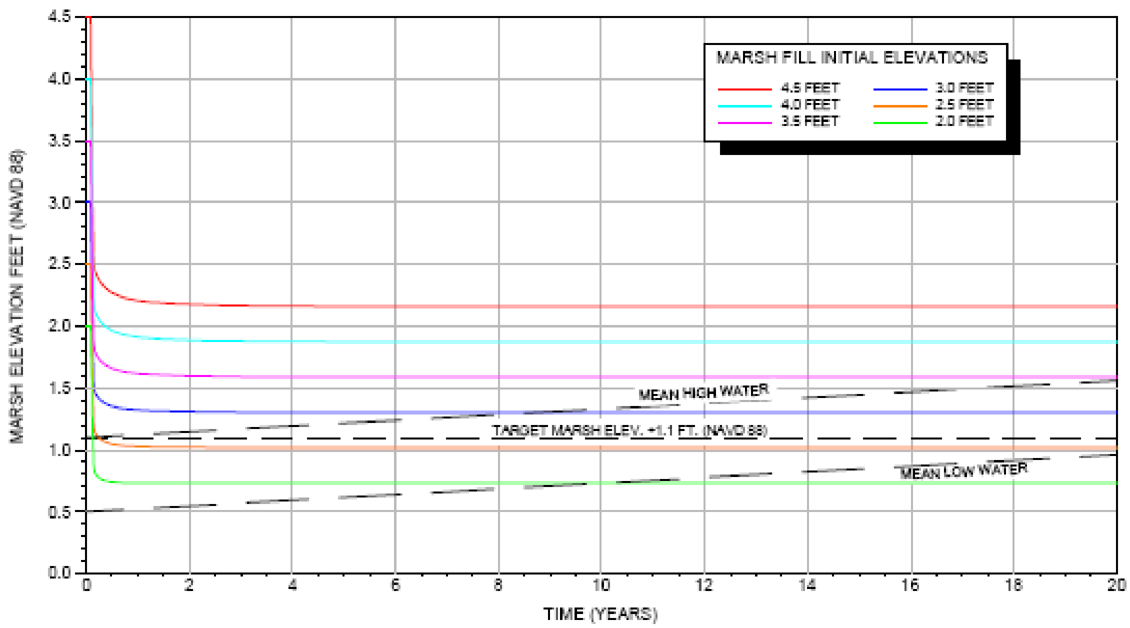


Figure 6: Settlement Curves for Boring 4

creation area over the design life of the project. Therefore, the internal containment dike placed in the marsh creation area during the 30% design has been removed. The entire marsh creation areas will be filled to the construction fill elevation of +2.5 feet NAVD 88.

For Marsh Creation Area 3, a construction marsh fill to elevation +3.0 feet NAVD 88 will be sufficient to reach the construction fill elevation while Marsh Creation Area 4 will require a construction marsh fill elevation of +2.5 feet NAVD 88.

3.5 Earthen Containment Dike Settlement Analysis

Settlement of the foundation soils beneath the earthen containment dikes were computed based on the dike geometries determined from the slope stability analyses. Reducing the crown elevation and width will decrease the amount of settlement under the earthen containment dikes. Settlement factors include regional subsidence, self weight consolidation, and elastic settlement of the in situ soils. Self weight consolidation is dependent on several factors, including organic content, natural moisture content, and construction methods. Elastic settlement of the in situ soils will occur quickly and will likely result in an increase in the quantity of fill required to reach the construction fill elevation.

Settlement for the earthen containment dikes was performed using an elevation of +4.5 feet NAVD 88. The actual design elevations ranged from +3.2 to +4.0 feet NAVD 88 and are based on the construction fill height in each marsh creation area.

3.6 Cut to Fill Ratio Recommendations

A cut to fill ratio was determined in order to account for losses due to dredging, containment and dewatering. The cut to fill ratio was calculated using the settling column test and the method outlined in the United States Army Corps of Engineers' EM-1110-2-5027. However, calculations using this method yielded a cut to fill ratio of approximately 2.2. Since this project is expected to be consistent with previous marsh creation projects having similar soil types which have yielded a cut-to-fill ratio of 1.3, a cut to fill ratio of 1.3 will be utilized for all marsh creation areas.

Similarly, previous projects have experienced a cut-to fill ratio of 1.5 to 2.0 for construction of earthen containment dikes by mechanical dredging. The PO-33 Goose Point Project attained a ratio of 1.5 for mechanical dredging using similar dredge material; therefore, a ratio of 1.5 will be utilized on this project.

3.7 Goose Point Fault

The borrow area for the PO-104 project lies just north of the Goose Point Fault, which is an extension of the Baton Rouge-Denham Springs Fault system that lies near the north shore of Lake Pontchartrain. The approximate location of the fault line is shown in Figure 4.

4.0 WIND ANALYSIS

Located along the northeastern shoreline of Lake Pontchartrain, a large portion of this project will be exposed to wind generated waves blowing across the lake. Therefore, wind data was analyzed from 3 stations around Lake Pontchartrain including New Orleans Lakefront Airport (KNEW) from 1996-2011, Slidell Airport (KASD) from 1999-

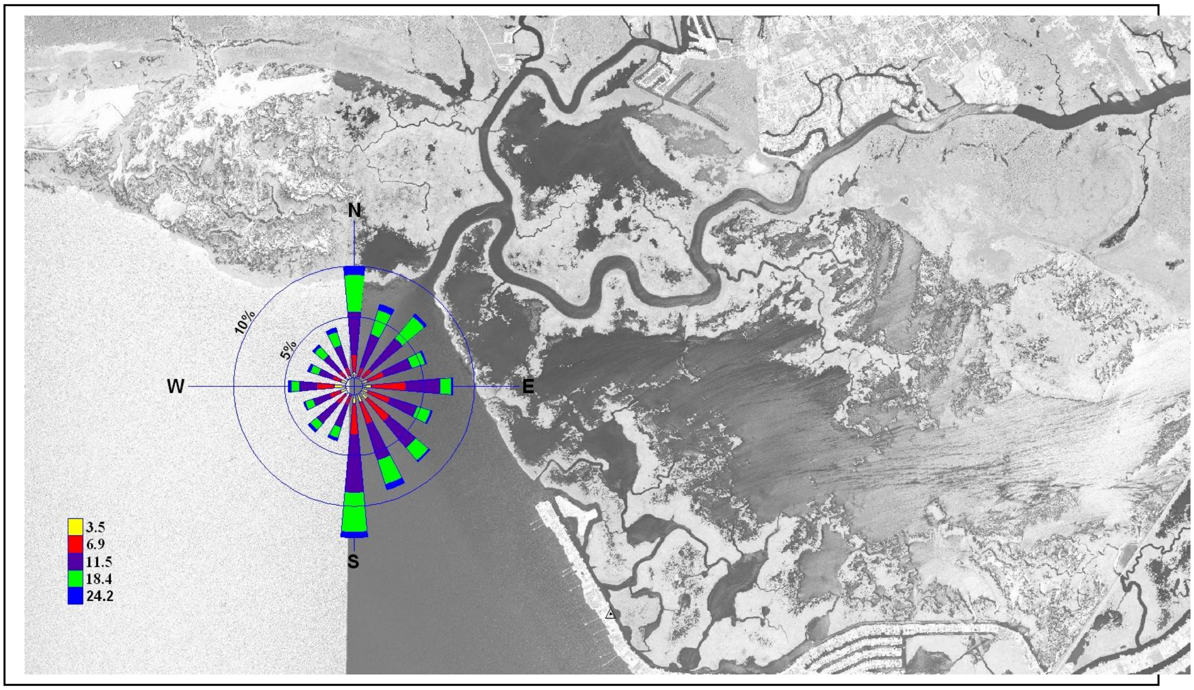


Figure 7: Louis Armstrong Airport Wind Rose

2010, and Louis Armstrong New Orleans International Airport (KMSY) from 1996-2011. Wind roses were developed for the three stations and are provided in Appendix F. These wind roses show maximum wind speeds originating from the north and south directions. Figure 7 shows how the west and southwest directions, which represent the largest fetch, have some of the lowest wind speeds. The maximum wind speed recorded was 69 mph at the Slidell Airport station. This wind speed suggests that the upper range of wind speeds were not collected due to instrumentation limitations since the time period of data collection extended through several major hurricanes. The statistical wind speeds are lower than actual due to the missing wind data. Based on a statistical analysis of the available hourly wind data, the 90th percentile wind direction was determined to be 166.8˚ clockwise from north (south-southeast). The wind speed associated with the 90th percentile wind direction was calculated to be 13.8 miles per hour. The 50th percentile wind direction was evaluated to be approximately 170˚ clockwise from north with an associated wind speed of 9.21 miles per hour. In order to capture the effects of an average daily wind on the project site, the 50% wind speed was used to develop the wave analysis.

The percentile wind speeds for all three stations were calculated and determined to be consistent as shown in Tables 4 through 6.

DEGREES FROM TRUE NORTH

	130-150	160-180	190-210	220-240	250-280
% Less Than	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr
100(max)	69.06	33.38	32.23	24.17	26.47
95	14.96	17.27	13.81	11.51	12.66
90	13.81	14.96	12.66	10.36	11.51
75	11.51	11.51	10.36	8.06	9.21
50	8.06	9.21	8.06	6.91	6.91
25	5.76	6.91	5.76	4.60	4.60

Table 4: Slidell Airport Wind Data (1999-2010)

DEGREES FROM TRUE NORTH

	130-150	160-180	190-210	220-240	250-280
% Less Than	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr
100(max)	35.68	40.29	35.68	32.23	37.98
95	17.27	18.42	19.57	17.27	20.79
90	14.96	16.11	17.27	14.96	17.27
75	11.51	11.51	12.66	11.51	12.66
50	8.06	8.06	9.21	9.21	9.21
25	5.76	5.76	5.76	6.91	5.76

Table 5: New Orleans Lakefront Airport-Wind Data (1996-2011)

DEGREES FROM TRUE NORTH

	130-150	160-180	190-210	220-240	250-280
% Less Than	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr	Wind Speed mi/hr
100(max)	29.93	31.08	37.98	29.93	40.29
95	16.11	18.42	17.27	14.96	17.27
90	13.81	16.11	14.96	12.66	13.81
75	10.36	12.66	11.51	10.36	10.36
50	8.06	9.21	9.21	8.06	6.91
25	5.76	5.76	6.91	5.76	4.60

Table 6: Louis Armstrong International Airport Wind Data (1996-2011)

5.0 HYDRAULICS ANALYSIS

5.1 Tidal Datum

Tidal variations can be considered as being comprised of periodic and apparent secular trends. In order to evaluate these variations, a specific 18.6-year period based upon the Metonic Cycle should be selected so that all tidal datum determinations will have a common reference period. This period is termed a tidal epoch. Unfortunately, Hurricane Katrina destroyed all tidal gages in Lake Pontchartrain; therefore, obtaining a continuous up-to-date tidal epoch in the area was not possible. Data from 4 local gages was evaluated for calculation of Mean High Water (MHW) and Mean Low Water (MLW) using the Range-Ratio Method and the Grand Isle Gage. The gage locations are shown in Figure 2. They include the United States Geological Survey (USGS) stations at Bayou Rigolets #0738023365 and Bayou Liberty #07374581, CPRA's Coast Wide Reference Monitoring Station (CRMS) 3667, and the United States Army Corps of Engineers (USACE) gage 85575 in Lake Pontchartrain near Mandeville. The Grand Isle gage is the closest gage that contains a continuous epoch. However, its large tidal ranges would skew the local tidal data in the Bonfouca project area. Therefore, no techniques to standardize the data such as the Range-Ratio method were utilized. A summary of the MHW and MLW levels, adjusted to NAVD 88, for each of the four gages mentioned above is shown in table 7.

Gage	Date Range	MHW (ft)	MLW (ft)
Bayou Rigolets USGS 0738023365	10/94 - 8/05	1.19	0.23
Bayou Liberty USGS 07374581	1/01 - 10/11	1.31	0.64
Lake Pontchartrain-Mandeville USACE 85575	1/95 - 9/11	0.92	0.37
CRMS 3667	1/07 - 12/10	1.07	0.75
(PO- 33) Goose Point Marsh Creation Project	NA	1.08*	0.48*

Table 7: Tidal Gage Data

The MHW and MLW levels demonstrate the tidal variability near the project area. This variability is believed to be related to the gages' location and hydraulic connectivity to the more dynamic Gulf system. The larger ranges occur in areas governed by Gulf tides while the lowest range occurs at the CRMS 3667 gage which is located in the interior marsh. The locations of these gages are shown in Figure 8. The average MHW and MLW of the four sites is 1.1 feet and 0.5 feet respectively. These values are similar to the values calculated for the PO-33 Goose Point Marsh Creation Project located immediately to the west of this project. To demonstrate the effects of location on the various tidal gages, a comparison of the tidal heights between the Bayou Rigolets and Bayou Liberty gages during the 48- hour period of October 17 & 18, 2007 is shown in Figure 9. A large difference in amplitude and a tidal lag exists between the two gages. The Bayou Rigolets gage is located in between Lakes Borgne and Pontchartrain and are very tidally influenced. In contrast, the Bayou Liberty gage is located farther away and, therefore, is less controlled by the tidal cycle.

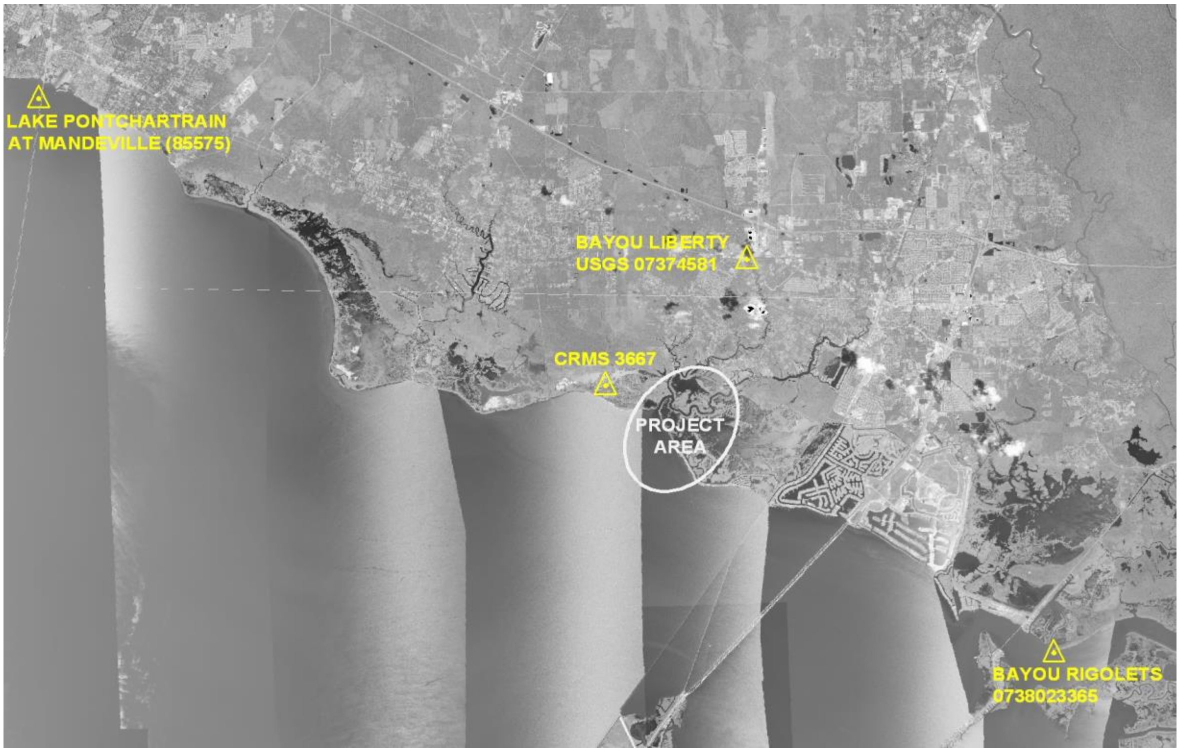


Figure 8: Gage Locations

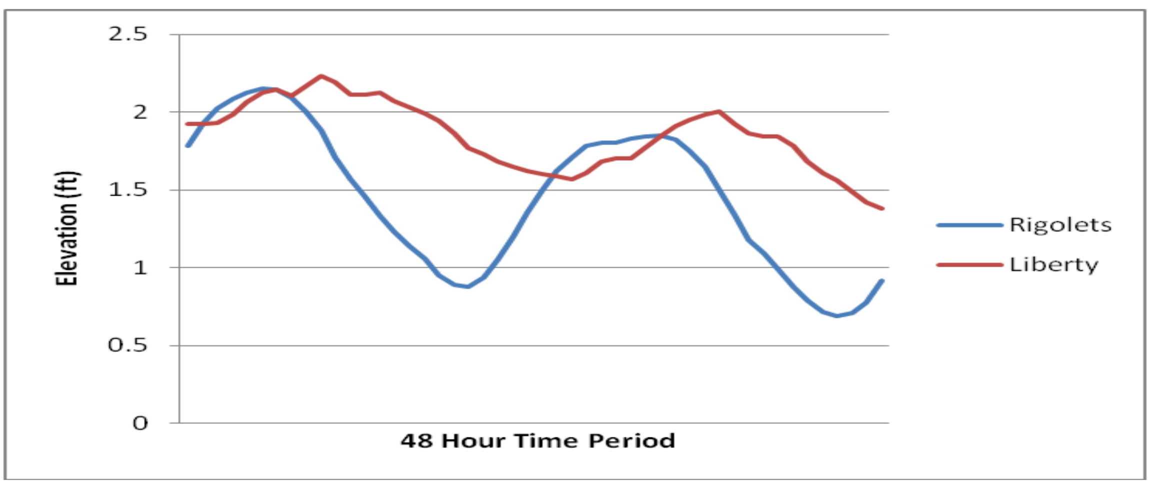


Figure 9: Comparison of Bayous Rigolets and Liberty's tidal graphs

5.2 Waves

Three wave generating scenarios were analyzed and are shown in Table 5. The wind across the longest fetch was evaluated using the 50th percentile winds at 260^{o} clockwise from north. The direction of fetch associated with the 90th percentile winds was evaluated using both the 50th and 90th percentile wind speeds. The U.S. Army Corps of Engineers Coastal Engineering Manual (USACE CEM) was utilized to develop the deep water wave height for all three scenarios.

The maximum height to which a wave will run up onto the shoreline can be estimated taking the sum of the setup, mean high water level and the wave height at a point near the shoreline. This number is identified in Table 8 as absolute wave height. For a conservative estimate the wave height at the -0.1ft contour was used.

Wind Direction (TN)	Wind Speed (MPH)	Wave Height (H) ft	Absolute Wave Height (H + setup + MHW) ft
260°	8.06 (50%)	0.34	1.59
170°	9.21 (50%)	0.49	1.69
170°	20.2 (90%)	1.1	1.99

Table 8: Calculated Wave Heights using Slidell Airport Data

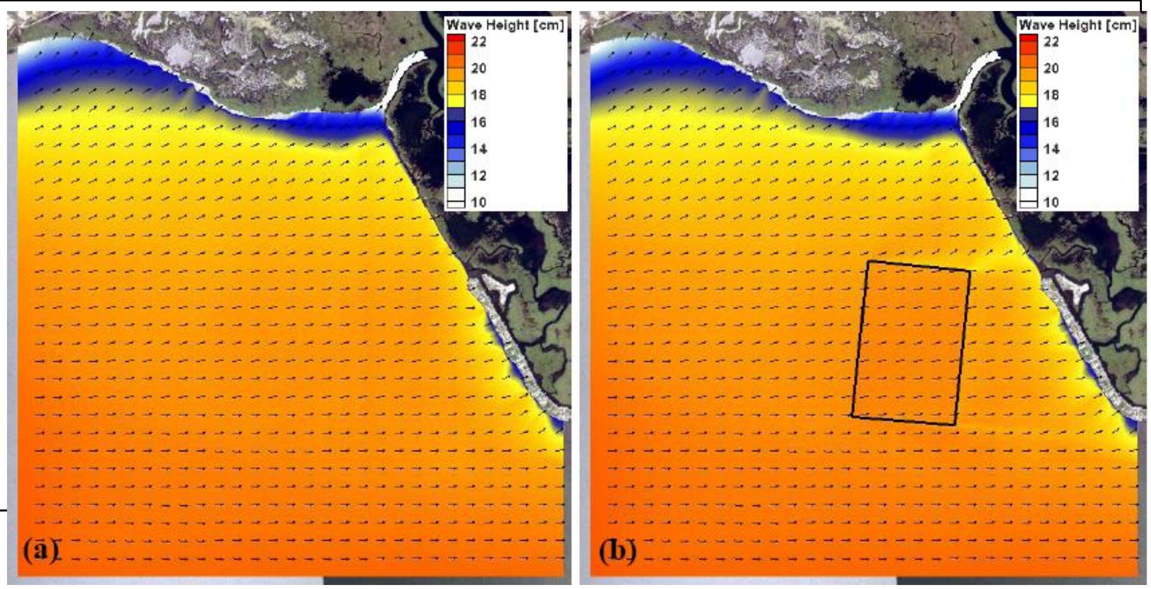
As shown in Figure 1, this project requires dredging of a 331 acre borrow area approximately 3,000 feet from the existing shoreline. As part of the borrow area impact analysis, the numerical model SWAN (**S**imulating **WA**ves **N**earshore) was used to assess both existing and post-dredge wave environments. SWAN is a spectral, two-dimensional wave generation and transformation model. Coast and Harbor Engineering, Inc. (CHE) performed this task for CPRA. Technical information regarding the SWAN modeling is available in Appendix C.

The input conditions for the numerical wave model were developed in coordination with CPRA for a total of 8 different scenarios, which are summarized in Table 9. The conditions consisted of the existing and dredged bathymetry scenarios, two water levels – mean high water (MHW) and mean low water (MLW), and the 50th percentile wind speed for two directions - 170° and 260° from true north (from nearby wind gages). Wave heights were then extracted at 3 points from the SWAN results to quantify the change in magnitude of the wave heights near the shoreline.

Wind Direction (TN)	Wind Speed (MPH)	Water level	Bathymetry Condition
260°	8.06	MHW	Existing
260°	8.06	MHW	Dredged Borrow Area
260°	8.06	MLW	Existing
260°	8.06	MLW	Dredged Borrow Area
170°	9.21	MHW	Existing
170°	9.21	MHW	Dredged Borrow Area
170°	9.21	MLW	Existing
170°	9.21	MLW	Dredged Borrow Area

Table 9: Scenarios for SWAN Input Conditions

Modeling showed that the excavation of the borrow area did not increase wave energy in any appreciable amount at the existing shoreline. The direction of waves around the edges of the borrow area are slightly changed due to wave refraction, but the magnitude of change is small. The maximum increase in wave height occurred at MLW for both wind directions analyzed, which resulted in only a 1 cm increase in wave height (~2% increase). The magnitude of change in wave heights computed by SWAN is determined to be insignificant due to the relative accuracy of bathymetry measuring instruments and



within the natural variability of waves at the project site. Figure 10 shows the predicted wave heights and set up with and without the excavation of the borrow area. The small increase in wave height is not expected to cause any significant shift in the existing morphological conditions at the project site.

When added to the MHW of 1.1 feet NAVD 88, the wave heights without excavation of the borrow area, 0.56 feet (17cm) = 1.66 feet, are consistent with the wave heights calculated using the USACE CEM.

6.0 SUBSIDENCE AND SEA LEVEL RISE

To determine the most likely change in sea level over time, CPRA utilized its Louisiana Applied Coastal Engineering and Science (LACES) Division to assist with calculating this value. LACES attempted to bracket this rate by providing a range to account for uncertainty. In order to calculate subsidence, LACES used the ranges of subsidence values shown in Figure 11. The figure was created using measured subsidence rates found in those areas. The Bayou Bonfouca area has some of the lowest subsidence rates (2-5mm/yr) in coastal Louisiana. The range for possible relative sea-level rise by 2032 calculated by LACES is 0.1304 m – 0.2412 m**.** This equates to a combined subsidence and sea level rise of approximately 5 to 10 inches over the 20 year design life of this project.

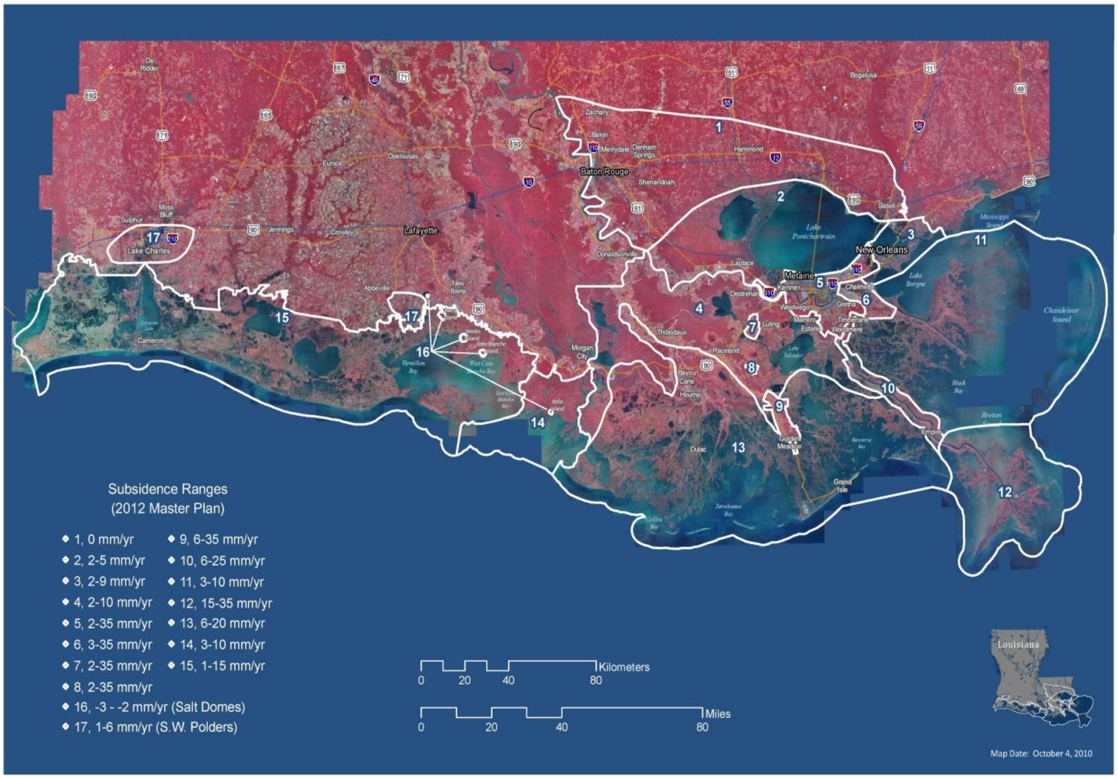


Figure 11: Map of Projected Subsidence Ranges for South Louisiana

The information provided by LACES represents the relative sea level rise (RSLR) that is expected to occur at a specific location and incorporates both Global Sea Level Rise (GSLR) and subsidence. However, studies indicate that historic rates of accretion would likely be sufficient to keep up with the predicted RSLR in the area over the project life (Reed et al. 2009)

7.0 MARSH CREATION DESIGN

This project proposes to create marsh by dredging sediment from Lake Pontchartrain for placement into the marsh creation areas shown in Figure 1. The marsh creation design was separated into four (4) components: marsh creation areas, dredge borrow area, ponds, and earthen containment dikes. The design of each component is discussed in the sections below.

7.1 Marsh Creation Area Design

The primary goals of the marsh creation areas are to address the widespread marsh loss in the area and to reestablish the integrity of the northern shoreline of Lake Pontchartrain. To accomplish this, earthen containment dikes will be constructed on the perimeter of the marsh creation areas and a slurry of hydraulically dredged sediment from Lake Pontchartrain will be placed within the earthen containment dikes to a specified construction fill elevation. A key component to this marsh creation area design involves the calculation of volumes required to fill the marsh creation area to the construction fill elevation. The construction fill elevation was governed by several factors including the healthy marsh elevations obtained from the survey, the tidal datum, the physical properties of the borrow material, and the bearing capacity of the foundation soils in each marsh creation area.

Determination of the construction fill elevation involved an examination of the existing marsh conditions. The marsh elevation survey revealed that the average healthy marsh elevation throughout the entire project area is approximately +1.0 ft. NAVD 88 (Section 2.3). The calculated tidal datum (MHW=1.1 ft., MLW=0.5 ft.) verifies that the existing marsh predominantly falls in the upper portion of the project inter-tidal zone, defined as the range of elevations that lie in between the upper and lower extents of the tidal datum.

In order to evaluate the performance of the created marsh over the 20 year project design life, the project team decided that the final target marsh elevation would be the criteria to judge the success of the project. Ideally, biologists from both USFWS and CPRA prefer the created marsh to be as close as possible to the existing marsh conditions and within the inter-tidal zone. This means that the final target marsh elevation (after initial consolidation and long term settlement) would need to fall within the upper range of the MHW and MLW. To achieve this, the marsh platform will initially have to be pumped to an elevation higher than MHW during construction and settle into the inter-tidal zone over the 20 year design life of the project.

After determining the construction marsh fill elevations, the total volume of each marsh creation area was calculated by using AutoCAD Civil software. The software creates a 3-Dimensional surface based on XYZ coordinate data from the survey cross sections. This surface is known as a Triangulated Irregular Network (TIN). The TIN model represents a surface as a set of contiguous, non-overlapping triangles. Both a TIN surface containing the 2011 survey data from C&C Technologies and a flat TIN surface at the specified construction fill elevation was generated by AutoCAD. AutoCAD then uses the XYZ differences of each surface to calculate the volume of each marsh creation area. Since the borrow material required to build the earthen containment dikes is located within the marsh creation area and must be refilled, this borrow volume is then added to the volume required to construct the marsh creation areas. The cut-to-fill ratio of 1.3 is then applied, resulting in a final estimate of volumes for each marsh creation area. Table 10 summarizes the fill volumes for each marsh creation area within the PO-104 project.

Marsh Creation Area	Fill Height (ft)	Area (Acres)	Volume of Fill (yd^3)
1	2.7	322	2,223,323
Ponds A&B	1.7	9	59,247
2	2.5	159	1,049,992
3	3.0	32	220,642
4	2.5	116	605,114
Total	NA	638	4,158,318

Table 10: Summary of Fill Acreage and Volume

7.2 Earthen Containment Dike Design

The earthen containment dikes will be constructed along the perimeter of each marsh creation area to allow for filling to the construction fill elevation. The earthen containment dikes shall be constructed using in-situ material from inside each marsh creation area. The primary design parameters associated with designing the earthen containment dikes include location, crown elevation, crown width, side slopes and the factor of safety for slope stability.

The crown elevations for the earthen containment dikes were determined by adding one foot of freeboard for dredge slurry containment to the construction fill elevation of the respective marsh creation area. For the ponds in Marsh Creation Area 1, a freeboard of 0.5 feet was utilized. This determination accounted for the projected settlement of the earthen containment dike.

The crown width of the earthen containment dikes is dictated by slope stability and was determined by providing a minimum factor of safety of 1.1. All earthen containment dikes will be constructed using a crown width of 5 feet except for two containment dike sections within Marsh Creation Area 1. The sections for the 2 ponds will have a 2 foot crest width. The 1,500 foot section along the shoreline of Lake Pontchartrain will have an 8 foot crown width in order to provide sacrificial protection against wind generated waves.

The side slopes of the earthen containment dikes are also dictated by slope stability and were determined by providing a minimum factor of safety of 1.1. A side slope of 3H:1V was utilized for all earthen containment dikes except for three sections within Marsh Creation Area 1. The eastern section will require 6H:1V side slopes, the 1,500 foot section along the shoreline of Lake Pontchartrain will require 4H:1V side slopes in order to provide sacrificial wave protection, and the pond sections will require 2H:1V side slopes. The earthen containment dikes will be constructed to the dimensions shown in Table 11.

Earthen Containment Dike (ECD)	Marsh Creation Area	Design Height (ft)	Side Slopes	Crown Width (ft)
ECD-1	1	3.7	4H : 1V	8
ECD-2	1	3.7	3H : 1V	5
ECD-3	1	3.7	6H : 1V	5
ECD-4	1- Ponds	2.7	2H : 1V	2
ECD-5	2 & 4	3.5	3H : 1V	5
ECD-6	3	4	3H : 1V	5

Table 11: Summary of Earthen Containment Dike Design

In order to maintain slope stability, the borrow pits for the earthen containment dikes shall be located at a minimum of 25 feet from the toe of the dike. Furthermore, the borrow pits shall have 3:1 side slopes and allow for a maximum dredge cut of 10 feet.

7.3 Ponds

A stipulation from a landowner for part of Marsh Creation Area 1 was that ponds be provided in the marsh creation area. Two circular ponds, 4-5 acres in size, will be created in the western portion of the marsh creation area. In order to accomplish this, the earthen containment dikes will be constructed around the perimeter of the ponds with two (2) small polar openings. Dredged material will be placed into Marsh Creation Area 1 and allow the slurry to fill inside and outside of the ponds. After the slurry reaches an elevation of +1.7 feet, the openings in the earthen containment dikes will be closed and the remaining portion of Marsh Creation Area 1 will be filled to the construction fill elevation of +2.7 feet NAVD 88. Earthen containment dikes for the ponds will only have six (6) inches of freeboard since some overtopping into the ponds is permissible.

7.4 Borrow Area Design

According to the Lake Pontchartrain Basin Foundation (LPBF), the grass beds in Lake Pontchartrain constitute productive underwater habitat. They provide critical food and shelter for juvenile fish and shellfish, and are responsible for about 25 percent of the fishing industry in the lake (LPBF, 2012). In order to protect these critical grass beds, the borrow area was located near the -10 foot contour which is well outside the normal depth at which the grass beds exist.

Gulf Sturgeon, a fish listed as threatened under the Endangered Species Act in 1991, are known to exist in this area. The USFWS has identified sand on the bottom of Lake Pontchartrain as a beneficial area for Gulf Sturgeon and therefore the borrow area was located to avoid such areas.

The proposed borrow area is approximately 331 acres with a maximum allowable cut depth to elevation -25.0 feet NAVD 88. Maintaining side slopes of 3H: 1V will provide approximately 7,752,600 cubic yards of available cut volume.

8.0 ARCHEOLOGICAL REVIEW

According to information received from the Louisiana State Historic Preservation Office (SHPO), at least three archeological sites are known to exist near the PO-104 project area. The sites are located on the lake ridge and along the banks of Bayous Bonfouca and Liberty. These are predominately shell midden sites with a light to moderate artifact density, at best. A formal consultation with SHPO has been initiated by the USFWS.

9.0 CONSTRUCTION

9.1 Duration

Due to Gulf Sturgeon habitat issues, the Goose Point Project, (PO-33), was given an initial dredging window from May 1st to September 30th which was later modified to include October. The construction duration was developed using the CDS Dredge Production and Cost Estimation Software. A 25% downtime rate was used for general maintenance and weather since the 153 day dredge window runs through hurricane season. Assuming that a 30 inch hydraulic cutter head dredge would be utilized, the construction duration is estimated to be 350 days.

9.2 Cost Estimate

A construction cost estimate for the PO-104 project was prepared using the CWPPRA PPL 21 spread sheet and is provided in Table 12.

Item	Quantity	Unit	Unit Cost	Total
Mobilization/Demobilization	1	LS	$2,062,900	$2,062,900
Hydraulic Dredging	4,158,318	CY	$3.75	$15,593,693
Earthen Containment Dikes	166,171	CY	$3.25	$540,056
Settlement Plates	8	EA	$3,500	$28,000
Construction Surveys	1	LS	$403,344	$403,344
ESTIMATED CONSTRUCTION COST				**$18,627,992**
ESTIMATED CONSTRUCTION COST + 25%				**$23,284,990**

Table 12: Construction Cost Estimate

10.0 MODIFICATIONS TO APPROVED PHASE 0 PROJECT

As a result of Phase 1 activities, a few changes have been made to the approved Phase 0 project. During further consultation with the USFWS staff at Big Branch Marsh National Wildlife Refuge, the design team was informed of a new breach along the rim of Lake Pontchartrain, west of the Phase 0 project footprint. The PO-104 project team recognized that adjustments should be made to protect the lake rim. Therefore, a new marsh creation area, Marsh Creation Area 4, was added and a comparable area was removed from the eastern side of Marsh Creation Area 1. The modified footprint is now 639 acres as compared to 591 acres proposed in Phase 0. The changes to the size and placement of the marsh creation areas will increase the overall size of the project by 48 acres.

During consultation with the landowners of Marsh Creation Area 1, one of the land owners was concerned about turning all open water into land because he leases the land to duck hunters. Therefore two shallow ponds were included in Marsh Creation Area 1 that will maintain a hydraulic connection with Bayou Bonfouca.

The borrow area was moved from its Phase 0 location to the current location farther into the lake to eliminate damage to grass beds on the lake bottom.

REFERENCES

GeoEngineers, Inc. (*Geotechnical Engineering Report for Bayou Bonfouca Marsh Creation Project (PO-104).* Baton Rouge, LA. March 2012

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United States Army Corps of Engineers, EM 1110-2-5027. *Confined Disposal of Dredged Material.* Washington, D.C. 1987

Lake Pontchartrain Basin Foundation (LPBF), *Environmental Changes around the Basin*, Retrieved April 4, 2012, from "http://www.saveourlake.org/"

DeMarco, K. E., J. Mouton., J. W. Pahl. (January 2012 Version). Recommendations for Anticipating Sea-level Rise impacts on Louisiana Coastal Resources on Project Planning and Design: Technical Report {HYPERLINK ""http://www.lacpra.org/assets/docs/LACES/LACEStech02_06_.pdf"}

Appendix A: Secondary Monument Data Sheet

Appendix B: C&C Technologies, Inc. Survey Drawings

Appendix C: SWAN Model Technical Letter

Appendix D: GeoEngineers Boring Logs

Appendix E: GeoEngineers Settlement Curves

Appendix F: Wind Roses

Appendix G: Construction Duration

Appendix H: 30% Responses to Comments on 30% Design

RESPONSES TO COMMENTS ON BAYOU BONFOUCA PROJECT (PO-104) 30% DESIGN

Joseph Guillory, CPRA

30% Plans

1. Comment on Sheet 2 - With regards to Note 10; if any modifications should need to be made to either the borrow and/or the beneficial use site(s) during the contract, it is assumed that "expansion" of a site would have been NEPA cleared.

   Response - As stated in Note 10, modifications would be made to reflect changes in field conditions. We are making every effort to consider and plan for any possible scenario that may arise; however, some changes in field conditions may occur very late in the design/construction process. If this is occurs, all efforts to alter the NEPA documentation will be made at the time we learn of the need for such modifications.

2. Comment on Sheet 2 - Under the "SUMMARY OF ESTIMATED QUANTITIES", Item No 8 is entitled "Grade Stakes", which agrees with the bid schedule of the specifications. However, this conflicts with the "Measurement and Payment" paragraph (2.9) on sheet 47 of the specs which labels bid item no 8 is "Construction Surveys". This discrepancy should be resolved.

   Response - Noted- will be resolved at 95%

3. Comment on Sheet 3 - Recommend that the location of the pipeline, which apparently runs immediately adjacent to and outside of the east end of marsh creation site 4, be verified prior to advertisement of this contract, rather than placing that burden on the dredging contractor as alluded to in Note 3. Also; were topographic surveys of the marsh creation and borrow sites performed? If so, were any pipelines, utilities, or other obstructions captured in that survey and are they all depicted on the plans?

   Response - As noted on plans sheet 3 the pipeline was probed to verify location and depth of cover; however, for safety reasons it is important for the contractor to verify location at the time of construction. Refer to section 3.1 “Topographic, Bathymetric and Magnetometer Surveys” of the preliminary design report.

4. Comment on Sheet 9 - With regards to the borrow area section at the top of this page, is the maximum grade of -25' NAVD88 the maximum depth that can be allowed by the dredge, or is the material below -25' NAVD88 not to be impacted at all? This needs to be clarified for the contractor as the dredge's suction depth could penetrate 3-3.5' below this grade in order to leave a final after dredging grade of approximately 25'. Any anticipated impacts below the -25' grade would need to be addressed in the NEPA documents in advance.

Response – The maximum depth allowed for cut will be -25'NAVD. The anticipated impacts below -25'NAVD will be addressed in the NEPA documents

5. Comment on Sheet 11 - With regards to Detail CD-3, based off of the grades and tolerances specified for the marsh with a fill elevation of +2.7' +/-0.5' and the proposed dike separating this marsh area from the proposed, adjacent pond site, it is possible that the dike could be initially be at the same elevation as the maximum slurry elevation of +3.2' which would leave no allowance to settlement of the dike during pumping and possibly lead to material flowing into the proposed pond site. If this would not be acceptable, then I recommend that the elevation of the dike possibly be increased to prevent any misplaced material.

   Response - The Earthen Containment Dikes only have a +0.5' (no minus) tolerance resulting in a low of 3.7 which will provide a minimum of 0.5' free board should the fill elevation reach the maximum design height of 3.2' NAVD

6. Comment on Sheet 23 - Based off of existing conditions, it appears that the elevation of the lake in the vicinity of the borrow pit ranges from -8' to -10'. Is floatation dredging for accessing the borrow site allowed, especially during low tide events? If so, are there any specified maximum floatation access channels dimensions, alignments, and disposal plans, or will the Contractor simply have to play the tide to possibly have to float in his/hers dredge plant?

   Response - Flotation dredging for access is not expected for this project. The dredge will be approaching the project from the south-east which has the deeper water, -10'NAVD. This coupled with the MLW of +0.5' NAVD will provide water depths of 10.5'. Furthermore, due to Gulf Sturgeon, the project will be constructed in the summer time when severe low tides are rare.

7. Comment on Sheet 23- On all borrow sections, for whatever reason, the plotted bottom of cut line for the templates is not straight and undulates across the template. Also, these sections show a borrow depth of -24' whereas the section shown on Drawing 9 of 27 shows -25' Max. Please verify which depth is correct.

   Response - Noted- will be resolved in 95% design submittal.

<u>30% Specifications</u>

1. Comment on Para SP-2, subpara 2.2 - The P&S do not specify/ define access for dredge pipeline into the 4 beneficial use sites. Access corridors that are to be used for dredge equipment and pipeline to access each site must be depicted on the plans.

   Response - All efforts to minimize the area affected will be made. The contractor will be required to present the corridor they intend to use to access the marsh creation areas in the work plan. Those sites will be for equipment and pipelines and will be strictly enforced.

2. Comment on Para SP-2, subpara 2.3- This paragraph states that any internal dikes (i.e. weirs) that may be required to maximize development of the 4 marsh creation sites shall be at no cost to the owner. In short, the owner will have to pay for these interior features. The Contractor is to include those costs under which bid item? Recommend stating that cost for any internal retention features that the Contractor might deem necessary shall be included in the applicable unit price(s) for each respective containment dike line item, or the applicable unit cost for dredging. Otherwise, the Contractors might front-load these "unknown and undefined costs" in the Mob and Demob to get more "upfront money" that may not even be required. The State's cost folks will also need to know this for cost purposes.

   Response - CPRA believes that this project can be constructible without internal dikes. However, some contractors prefer to utilize internal dikes in order to provide better control of the dredge slurry. Therefore, CPRA will allow internal dikes to be constructed. A cross section of the dike must be provided in the work plan and quality checks must be made to ensure that section is constructed as approved by the engineer. The specifications require that the cost for building dikes be included in the associated earthen containment dike bid items.

3. Comment on Para SP-15 PIPELINE LEAKS - If the leak results in misplaced material within say the Bayou Bonfouca channel, the misplaced material must be removed and the channel restored to the pre-existing condition. Remediation for misplaced material needs to be addressed.

   Response – The comment will be addressed in the 95% design submittal

4. Comment on Para 4.2 Access - Paragraph makes reference to "approved Access Corridors shown on the Plans.". However, no access corridors could be found on the plans.

   Response - The wording has been changed to “Construction access shall be through open water to the greatest extent possible. Access which requires travel across existing marsh must first be approved by the Engineer. Access through any marsh located outside of the project boundary is prohibited unless approved by the Engineer.

5. Comment on Para 4.4 Degradation of Containment Dikes - Some of the guidelines in this paragraph leave work up to "the discretion of the Engineer". How is the Contractor supposed to be able to quantify and cost out this effort if the work is discretionary? Also, is there a certain timeline following placement of material within each marsh site at which dikes will be degraded? Just need to be

sure that dikes are not degraded too soon where there could be a risk of losing dredged material outside of the marsh creation site(s).

Response - Concur. A provision for up to 15% of the total linear feet of containment dikes is included in the 95% specifications. 95% specs will contain more detailed information on when dikes should be degraded.

6. Comment on Para 5.4 Placement of Fill Material - How much fill will be allowed upon existing marsh within the marsh creation sites needs to be defined (i.e. 1' max) "Excess runoff of spoil" needs to be further defined for the contractor.

   Response - The elevation of the fill for each marsh creation area is defined in the specifications. TS-10.11 requires that any material deposited outside the marsh creation areas must be removed at the expense of the contractor.